SURFACE COATINGS

TECHNICAL FIELD

The present invention relates to protective coatings. Specifically the invention concerns hard, ductile, corrosion, wear and oxidation resistant surface coatings which can applied on substrates by thermal coating.

BACKGROUND OF THE INVENTION

It is generally known to provide surfaces subjected to harsh conditions such as excessive wear, corrosive environment etc with protective coatings. The coatings are applied in the form of powdered materials by methods such as thermal spraying and plasma arc welding etc. Depending on the final use of the coated substrate a large variety of powdered metallic materials have been developed.

The base element of the powdered material is frequently nickel and a common alloy system used is nickel alloyed with silicon and boron. In order to make the powder melt at a lower temperature the powdered material may include phosphorous as is disclosed in the US patents 4 231 793 and 5 234 510.

A problem with these powders, especially when it is desired to apply the coating rapidly using a high energy input, is that the molten powder, when applied to the substrate, has too low viscosity which in turn results in difficulties to restrict the melt on a specific surface area of the substrate. According to the present invention it has been now found that this problem may be minimized or even eliminated by adding controlled amounts of copper or iron to the powdered material which is to be applied on the substrate.

The use of copper in connection with protective coatings intended for copper based substrates is

disclosed in US 5 496 391. According to this patent the copper should be added in amounts above 5 % by weight and even up to 30 % by weight in order to avoid problems related to poor wettability of the copper containing substrate and poor machinability.

According to the present invention it has been found that powdered materials including less than 5 % have a beneficial effect on the viscosity of the molten powder whereas copper additions above 5 % by weight markedly deteriorates the appearance of the surface coating which is unacceptable.

An essential feature of the present invention is also the inclusion of carbide forming elements in the powdered material. The inclusion of small amounts of such elements will make the final coating more ductile which is believed to depend on a phenomenon generally referred to as grain size refinement. With higher amounts of carbide forming element it is also possible to get coatings having improved hardness.

Summary of the invention

In brief the present invention thus concerns a nickel based powdered metallic material comprising in addition to nickel, less than 5 % by weight of copper, less than 5.0 % by weight of iron, a carbide forming element, boron, silicon, phosphorus carbon and inevitable impurities.

Detailed description of the invention.

Specifically the present invention concerns a nickel based powdered metallic material comprising, in addition to nickel, 0 - 4.5 % by weight of copper, 0 - 5.0 % by weight of iron, whereby the total amount of copper and iron is at least 2.5 % by weight, 0.05 - 5.0 % by weight of a carbide forming element, 0.5 - 2.0 % by weight of boron, 1.0 - 4.0 % by weight of silicon, 0.5 - 4.0 % by

weight of phosphorus, 0.01-0.5 % by weight of C and less than 2 % by weight of inevitable impurities.

Effect of copper and iron

If the amount of Cu is less than 2.5 percent effect on the viscosity has shown to be too low, resulting in great demands on the skill of the person applying the powder to the substrate. On the other hand, if the amount of copper is larger than 4.5 % the appearance of the surface coating will deteriorate, which makes it difficult to apply several layers. If the viscosity is still too low i.e. with the addition of 4.5 % of Cu we have found that iron may be added in order to increase the viscosity and thus make it possible to obtain uniform layers without deteriorating the appearance of the final surface coating layer. In such a case the amount of iron should be less than 5.0 percent and preferably less than 3.0 percent. It has also been found that the copper could be replaced by iron. However the total amount of copper and iron should not be less than 2.5 % in order to reach the beneficial effects on the viscosity.

Effect of carbide forming elements

Another essential feature of the powder according to the present invention is the presence of carbide forming elements. These carbide forming elements may be selected from the group consisting of chromium, tungsten, molybdenum, vanadium, tantalum, niobium, titanium and zirconium and manganese. Without being bound to any specific theory it is believed that small amounts of these elements, such as 0.05-1.0 % results in grain size refinement of the structure of the final coating. The key feature of inoculation is related to the nucleation during solidification. The inoculants consist of the precipitated carbides. The obtained structure will be finer which is advantageous as the obtained coating will have a high ductility. This will also slightly increase

the hardness. Comparatively high additions of carbide forming elements, such as between 1.0 -5.0 % by weight, will increase the hardness and wear resistance but this will also make the machinablity of the applied surface coating more difficult. Thus the amount of carbide forming element should vary between 0.05-5.0 % by weight.

In the event that the substrate to be provided with the surface coating is cast iron, the carbides may be formed in situ, i.e. the formation of carbides occurs by picking up carbon from the substrate. Thus, when the powdered metallic material is applied to the cast iron substrate surface, the carbide forming element reacts with the carbon in the substrate resulting in the formation of carbide, by way of example chromium carbide. In this case the powdered material to be applied on the substrate includes a metal such as those listed above which have an high affinity to the carbon of the cast iron substrate. This must be taken into account when designing the metal powder due to the fact that cast iron is frequently used and comparatively inexpensive.

Furthermore, in the case that the substrate is cast iron the amount and type of carbides formed during the application process depends on the temperature provided, since the amount of carbon that is set free during the application depends on the temperature conditions on the substrate. The higher temperature, the more carbon is set free, and accordingly a larger amount of carbide is formed. It should be understood that other parameters also influencing the carbide formation are, by way of example, the time that the substrate is being heated during the application and the distance between the heating source and the substrate surface. Further, the preferred temperature depends of the carbide forming element used. By way of example, if chromium is used, the preferred temperature at the heating source, i.e. the fusing temperature is 850-910 °C. Accordingly, it is

essential for the invention that the amount of carbide and thus the hardness of the coating can be controlled by not only the choice and amount of carbide forming element but also the fusing temperature provided during the application.

Effect of carbon

The carbon is used in amounts between 0.01 - 0.5 % by weight. Carbon together with the carbide forming element precipitates as carbides in the surface coating. The amount of carbides is related to the amount of carbon and carbide forming elements.

Effect of Boron and Silicon

The addition of boron and silicon is used for increasing the wettability but also for lowering the melting point. Also, the combination of boron and silicon works as a fluxing agent. Further the addition of silicon adds oxidation resistance to the coating. The amount of boron is 0.5- 2.0, preferably 0.6-1.6 % by weight of the composition. The amount of silicon is 1.0 - 4.0, preferably 1.6-3.5 %by weight.

Effect of Phosphorous

The amount of phosphorous is 0.5 - 4.0, more preferably 1.5-3.0 percent. The main purpose of the addition of phosphorous is lowering the melting point of the powdered metallic material. The amount is preferably sufficient for achieving a melting temperature affordable for the coating to be applicable by means of conventional methods such as powder welding. The present composition of the powdered metallic material has shown to provide a melting temperature of around 850°C which can be compared with around 1050°C without phosphorous. Before applying the powdered material onto the substrate it is preferred to preheat the substrate to a temperature in the range of 300-800 °C.

The surface coatings are generally applied to the substrate on a specific wear exposed area or over an entire surface. The coating is thereafter machined for supplying a true gauge surface or a desired texture. Thus, it is of great importance that the coating although providing the desired hardness can be machined using conventional equipment.

The application of the surface coating can be performed manually or be automatized, and irrespective of method chosen it is a generally known problem that there sometimes are problems when building layers of large thickness as the viscosity in the weld pool might be to low. The low viscosity results in dripping effects which makes high demands on the skill of the person performing the application. On the other hand, if the viscosity in the weld pool is too high it is difficult applying even layers.

The melting temperature of the used powdered metallic material must in addition not be too high, since the available maximum fusing temperature with conventional equipment is limited and the melting temperature of the substrate must also be taken into account. The melting temperature is also important since a reasonable melting temperature provides the possibility of speeding up the application process.

When the carbide forming element is present in the upper part of the above range a coating that is machinable but still provides sufficient hardness to withstand the harsh conditions prevailing in e.g. glass moulds.

The powder composition also includes carbon. The amount of carbon is decided by the required properties of the final coating. Thus if the substrate is cast iron carbon from this substrate may diffuse from the cast iron into the coating and the prealloyed carbon will be set lower.

The powdered metallic material is manufactured by conventional methods such as water atomization or gas atomization. The particle size is adapted to the application method being used. By way of example, if the powder is applied by powder welding the particle size is often in the range of 20-106 μm. On the other hand, if the powder is applied by PTA, the particle size is often in the range of 45-150 μm.

To enhance the wettability and to better control the formation of carbides the substrate is preheated before application of the powdered material. The preheating is preferably uniform throughout the thickness of the substrate and is thus suitable performed in an oven. The temperature can be varied depending on e.g. the purpose of the coating and available equipment. Generally the temperature interval is 300-800 °C. The preheating reduces the affordable application time since the melting of the applied powder on the substrate surface occurs faster. On the other hand, the affordable time can also be reduced by e.g. increasing the fusing temperature.

Examples

The invention is further illustrated by, but should not be limited to, the following preparations and examples.

EXAMPLE 1

A powdered metallic material of the composition according to table 1 below was prepared by gas atomization and applied on a cast iron substrate containing 3.2 % by weight of carbon and also on a substrate of mild steel having a carbon content of about 0.1 % by weight. The hardness HV30 of the coating on the cast iron substrate was 299, whereas the hardness of the coating on the mild steel substrate was 280. The higher hardness of the coating on the cast iron substrate results from the carbon pick up from the cast iron.

Table 1

Composition	% by weight
Cu	3.9
Fe	0.1
Cr	0.2
B	0.9
Si	2.2
P	2.1
C	0.03
Ni	Bal
Impurities	<1.0

Additionally the powdered material having the above composition could be applied at high temperature without problems because of the relatively high viscosity. The wettablilty to the substrates, cast iron and mild iron, was without remark. Also the appearance of the final coatings was acceptable.

Example 2.

A powdered material having the composition according to table 2 was prepared.

Table 2

Composition	% by weight
Cu	1.7
Fe	1.5
Cr	4.9
B	1.2
Si	3.1
P	1.9
C	0.17
Ni	Bal.
Impurities	<1

Also this powder was prepared by gas atomisation. The hardness HV30 of the coating on the cast iron substrate

was 402, whereas the hardness of the coating on the mild steel substrate was 380. Thus also in this case an effect of the pick up of carbon from the cast iron substrate could be observed. Furthermore, as in the previous example, the powder was applied at high temperature and the viscosity was sufficiently high for applying the coating without problems. The wettablity to both the substrates was quite acceptable as was the machinability of the coatings.